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THE NEW OIL AND GAS DEPOSITS IN THE VIENNA BASIN

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After World War II, as we know, by the terms of the Potsdam Agreement, the Soviet Union obtained, in lieu of reparations, the oilfield and drilling-concession properties in East Austria owned or held by Germans, among other German holdings.

After a short period during which installations were taken down, the competent Soviet authorities decided to resume prospecting and research, and combined the sequestered petroleum enterprises into the "Soviet Petroleum Administration in Austria." Drilling resulted in the discovery of the Matzen and Aderklaa oil fields and the Zwerndorf gas field. Natural gas or petroleum were also found variously in the bensburg and Kagran structures, and prospecting in these areas has not yet been completed.

Recovery of petroleum, which amounted to 32,858 t in 1937, attained its first maximum in 1944, when 1,213,515 t were produced, but fell to 451,703 t as a result of the course of the war in 1945.

It was only in 1949 that the million-ton mark was again passed. Thereafter, production increased rapidly, attaining 3,666,112 t in 1955. The extensive scientific data resulting from the large-scale prospecting work of the Soviet Petroleum Administration was turned over to the Austrian administration in August 1955, along with the industry itself, consequent upon the conclusion of the State Treaty, and is gradually being published for the benefit of the interested parties.

Many stratigraphic and geological units and mineral deposits still demand fundamental study, so that here we can report only on the most significant results obtained in the last few years.

Aside from the small, abandoned deposit at Leoprechting, and the small gas occurrence at Wels in Upper Austria, all the petroleum and natural gas fields of Austria are in the Vienna Basin. The fundamentals of the geology of this area were published in coordinated form by Janoschek in 1943 and 1951, but the drilling conducted during the past decade has added significantly to our knowledge of the structure of this geological entity, as may be seen from the map sketch in Figure 1. (All references are listed at the end of this article).

The shape of the Vienna Basin was determined by a lateral curvature of the Alpine-Carpathian bow, which is continuous until the Helvetian. The activity of the fault may be traced from the Tortonian. Settling, sedimentation, fault formation, and a slight warping of the strata occurred simultaneously, so that the thickness of layers within the individual fault blocks and steps depends upon their tectonic position. As the Vienna Basin rests on an Alpine foundation, the Flysch zone, northerly limestone Alps, and crystalline central zone continue underground in a northwesterly direction.

The strata within the basin are from the Helvetian, Tortonian, Sarmatian, Pannonic, and Upper Pliocene. The Helvetian is present as marine (marl) development, brackish and strongly sweetened. The Tortonian is purely marine, and the Sarmatian brackish. The border between them is not always clear. Transitional developments may be seen at Aderklaa, Rabensburg, and other places. The Lower and Middle Pannonic are like the brine of the Caspian, while the Upper Pannonic is completely sweetened. The boundary between the Upper and Middle Pannonic was first properly defined by Friedl, in 1948, in studying the results of structure borings. He identified it as the most important guide horizon of the Vienna Basin. This knowledge provided the basis for the discovery of the new deposits, except for Aderklaa. The minerals filling the basin are chiefly clay-marl, sands, and sandstones. Only in the Pannonic do clays play a larger role. Thamnium limes are found in the Tortonian where deposition of terrigenic materials was reduced at points where the water was shallow.

The general profile presented in Figure 2 depicts the stratigraphic and lithological structure of the most important oil and gas fields, old and new, and the correlation of strata therein. This lithological structure is shown by 2 profiles through the Austrian portion of the Vienna Basin (Figure 3).

The central portion of the Vienna Basin (Matzen-Aderklaa) reveals itself as the most important tectonic unit. The map sketch in Figure 1, and Janoschek's 1955 relief map of the strata comprising the basin, show this area to be bounded on west and east by structural depressions. In the west there is the Kagran depression. Here, the Tortonian, 1,200 m thick, is still in the process of sinking, while in the vicinity of the Matzen structure it is only 600 m thick. This depression continues to the north in a channel-like area directly east of the Steinberg Fault. In the east, the central block, as we may call the Matzen highland, is bounded by the Las Lake depression. In the north this region is ended by a depression running directly across the axis of the basin, in which, according to geophysical studies (see Janoschek, 1955), the basin fill exceeds 5,000 m in depth. The northern and southern boundaries of this syncline are probably marked by faults.

The southwestern limits of the central block are marked by the Leopoldsdorf dislocation, long familiar.

The Steinberg Fault, discovered by Friedl in 1935, is a tectonically important element in the picture. The downthrow of this fault system, falling off to the east, varies, and exceeds 2,000 m at the upper edge of the Tortonian in the area of the Steinberg.

The older oilfields, Muehlberg-Hohenruppersdorf, relate to the Steinberg Fault. The faults discovered in the course of recent prospecting, bounding the Matzen and Aderklaa fields in the west, are to the west of the foregoing. All further, and less significant, fault lines in the Vienna Basin may be read from the sketch map. The former concept of the Vienna Basin as a stress zone has been confirmed by recent prospecting, although overthrust faults have not been found anywhere. However, as most of the deposits constitute anticline structures, the formation of which required lateral pressure, we are faced with a distinct, and as yet not fully clarified, contradiction.

The Oil and Gas Fields

The deposits of the Vienna Basin may be defined as consisting of a northern group (Muehlberg, Rabensburg, Neusiedl a.Z., Van Sickle, Goesting, RAG, Gaiselberg), and a southern (Matzen, Aderklaa, Kagran). In addition, there is the Zwerndorf gas field (lying in part on the frontier and continuing on the Czech side), and the small Enzersdorf-Schwadorf gas field.

The center of the petroleum industry in Austria at present is the Matzen field. Of the 3,670,000 t of oil obtained in the Vienna Basin in 1955, 2,870,000 t come from this field, and 75% of this from the Matzen sands. In the Matzen, the Helvetian, Tortonian, and, to a limited degree, the bottom of the Sarmatian, there are oil-bearing strata. Gas horizons are found in the Sarmatian and the lower Pannonic.

The Cretaceous Flysch, constituting the foundation of the basin, rises northward or northwestward, so that it has been reached in the borings in the northern half of the field. The Upper Cretaceous Flysch consists of solid gray sandstones, clay-marl schists, gray and red clay schists.

The Helvetian, which is over 600 m thick, lies over the Flysch and approximately parallel to it. The sandstone deposits have been identified by Friedl as consisting of 16 horizons. The upper portion of the Helvetian, comprising about 10 horizons, consists of gray and variegated (brownish, reddish, grayish) clay marls, and gray sandstones with freshwater Ostracoda. The lower portion consists solely of gray rocks and reveals the saline character of the Sarmatian. A series of cores have revealed these horizons, chiefly lenticular in development, averaging 25% porosity and 20 to 100 m d in permeability, to yield a light paraffin oil with a density of 0.820 to 0.860 (all densities at 20°C). Production is presently 1% of the total from Matzen.

The Tortonian lies above the Helvetian in disorderly fashion. It consists of clay-marls and sand strata, which Friedl identifies as consisting of 16 horizons. The Tortonian is 600 m thick. The most important oil-bearing stratum is the Matzen sand overlying the Tortonian. As it frequently merges with the Helvetian sands into a unified complex, Koelbl holds, in an unpublished report, that it is sensible to designate only the Tortonian portion as the sixteenth horizon, while the complex as a whole should be termed Matzen sand.

The productive portion of the Matzen sand forms an anticline structure about 10 km long, and 3 km wide. The Matzen sand can be traced, as a lithological body, for a length of 25 km and a width of 12 km. The longitudinal axis of this structure runs WSW-ENE. The surface of this structure is divided into 3 levels, which coincide with the zone of maximum permeability, and have been identified by Koelbl (1956) as aggradation forms. The thickness of the productive layer ranges from 10 to 80 m, the mean being 28 m.

The grain size of the sand is between 0.5 and 0.02 mm, although here and there larger grains are found, and occasional Flysch and limestone alpine gravel. The minimum grain size is 0.3 to 0.2 mm, expressing itself often in a grain-size distribution curve with 2 maximums. This is apparently to be ascribed to the admixture of genetically diverse materials.

The Matzen sands consist 90% of quartz grains. The feldspar content (microline plus plagioclase) is slight, as is that of muscovite and glauconite. Biotite is virtually completely absent. Carbonates are found both in the detritus and in the binder. The percentage of limestone components rarely exceeds 5%. The total carbonates of the Matzen sands come to from 1 to 10%, of which 1 to 3% are $MgCO_3$, which is bound in the dolomite components. Heavy minerals constitute only a few tenths of one percent. Magnetite and ilmenite are found frequently, pyrite seldom. Garnet and zircon are the most common of the translucent heavy minerals. In declining order one encounters tourmaline, staurolite, rutile, and, more rarely, titanite, cyanite, and apatite. A classification of the heavy-mineral content by grain size should be undertaken. The coarse-grained types contain more garnet, the finegrained more zircon. In the Matzen sands, as in the Helvetian, there is more tourmaline than staurolite. The Matzen sands are distinguished from the sands and sandstones of the overlying and underlying strata by their low carbonate content.

Consolidation is slight in general, although there are occasional cemented areas, in which the carbonate content is correspondingly higher.

The average porosity is 28%, but it is sharply reduced in occasional spots with carbonate cementing, particularly of the superstratum. Permeability to air attains a maximum of 4,000 md, b declines to 10 ... northern and southern edges of the structure. An unpublished report by Kaufmann states that the weighted average permeability, determined from values ascertained in the field, is 2,000 md for the productive portion of the field. The substance obtained is a naphthene paraffin base petroleum, density 0.907, while the initial GOeV was 51 Nm^3/m^3, and the original pressure corresponded to the hydrostatic.

The second most important oil-bearing stratum is the eighth Tortonian level. The center line of this horizon is 500 m to the south of the sixteenth Tortonian, and its stratification is exceptionally smooth and plateaulike. The northern edge drops a bit.

In the west the eighth Tortonian, like the entire deposit, is intercepted by the Bockfliess fault. In the south and east it is highly contaminated by marl.

The average thickness of the sands in this horizon is 15 m. It consists of a number of layers of sand, of which the topmost is highly permeable. Fine layers may be distinguished throughout. The deposit took shape in shallow water, while an autochthonic Thamnium grus is found in the overlying and underlying strata and in the clay-marls between the permeable sands. As the Thamnium grus, intermixed with the typical Leitha lime fauna, is limited in depth, this deposit occurs in the Tortonian.

In the eighth Tortonian horizon, grain sizes in excess of 0.3 mm are virtually entirely lacking. The maximum diameter of the more or less symmetrical grain-size distribution is between 0.2 and 0.06 mm.

The major components are quartz, about 70%, and carbonates, 27% (lime and dolomite components as well as carbonate binder). Microline and plagioclase do not constitute more than 2% of the whole, at the most. Muskovite and chlorite are rare. Biotite and glauconite are virtually entirely lacking. Consolidation of the mineral is slight. The clay minerals occurring in the fine grain sizes have not yet been studied. However it would necessarily seem that they consist primarily of illite (according to Siegl's investigation).

Heavy minerals total 0.3 to 0.9%. The opaque grains consist of magnetite, ilmenite, and pyrite. Garnet is the most common component of the translucent fraction. Zircon is present in varying amounts. Staurolite and cyanite are better represented in the eighth level than in the sixteenth, which is to be ascribed to a greater accession from the Bohemian massif. Tourmaline, on the other hand, is less well represented. Rutile, titanite, and apatite are found in varying amounts.

The average porosity is 28%, and the average carbonate content, 26%. Reduced porosity, due both to the presence of carbonate binders and to the filling of the pores by clay, has been observed. Permeability to air has been found to attain 8 d in the upper sand layers of the northern portion of the structure, but it declines sharply after the marl intermixture zone has been reached.

This horizon contains a naphthene-base petroleum, with a density of 0.93.

The structure of the ninth Tortonian is similar to that of the eighth, and it contains the same kind of petroleum. The tenth to the fifteenth horizons are primarily lenticular, and, unlike the foregoing, contain oil only in a limited area. They resemble the eighth and ninth horizons in mineralogical and petrographic composition and in petrophysical content. The same holds for horizons one to 7. Horizons 3,5,6, and 7 show sporadic petroleum content. The fourth horizon contains gas. The oil-bearing horizons have gas pockets of virtually pure methane throughout.

The Sarmatian has a mean thickness of 350 m, and consists of 10 sand horizons. Horizons 1 to 5 belong to the Nonion granosum zone, and are each 10 to 30 m thick.

In terms of mineralogy and petrography, and in petrophysical content, these horizons differ hardly at all from the Tortonian. In the Upper Sarmatian, epidote is found in addition to the heavy minerals discovered in the Tortonian. The porosity and permeability are similar to those of the eighth and ninth Tortonian, although relatively little test material has been taken. The eighth Sarmatian has been found to contain a little oil. Locally, horizons 4 to 8 contain gas.

The Lower Pannonic is about 250 m thick, and consists of 5 sand horizons which are separated by clay or clay-marl. These horizons are 10 to 40 m thick. The third, fourth, and fifth contain gas. The gases of the Sarmatian and Pannonic consist of virtually pure methane. The initial pressure of the deposit corresponds to the hydrostatic. The Middle and Upper Pannonic contain no useful hydrocarbons.

The Aderklaa structure was discovered as long ago as 1934 by torsion balance measurements. The wells sunk prior to December 1938 yielded only gas and condensate at 2,400 m. It remained for the Soviet Petroleum Administration in Austria to find an oil-bearing horizon at about 1,700 m, both by new drilling and by the use of old wells.

The foundation of this field consists of rocks of the limestone alpine zone. Above this there are 660-to 770-m thicknesses of clay-marl and sandstone from the Helvetian, which yield freshwater Ostracode debris as their only fossil material. The Tortonian starts with the 210-to 280-m thick Aderklaa conglomerate, containing both gravel strata and abundant sand. The gravel originates chiefly in the limestone Alps. The Aderklaa Conglomerate is not a local formation, but extends throughout the southern portion of the Vienna Basin as the underlying conglomerate of the Tortonian. Tongues of this formation reach to the southern boundary of the Matzen structure. The make-up of the gravel varies greatly from place to place. Above the conglomerate one finds the Aderklaa sands which, with the clay-marls separating them, form a series of deposits up to 150 m thick. Of the five sand layers (horizons 3 to 7), the fifth is particularly important as an oil-bearer. Contact surface between oil and water in this horizon is uniformly at 1,572 m below sea level. Above this, there are 550 m of clay-marl with nonproductive intercalations of sand at the boundary between the Sarmatian and the Tortonian, and in the upper third of the marl layer, corresponding to the eighth Tortonian at Matzen. The 350 m of the Sarmatian corresponds almost exactly to the Matzen Sarmatian, but contain no productive horizons whatever.

It is noteworthy that the Aderklaa sands yield a light petroleum, density 0.81. In its original state, this oil was apparently undersaturated, and gas pockets have not been found anywhere. As the edge water is not active, there is internal gas pressure in the deposit. The Pannonian and Sarmatian reveal development similar to that at Matzen, but contain less sand.

Second in importance is the Muehlberg field. Here prospecting was begun in March 1941 and was carried further and completed toward the end of the war.

This field lies in the sunken block east of the Steinberg fault. The structure is a dome, and has been modified by faults of little throw. The stratification consists of 450 m of Pannonic, 550 m of Sarmatian, and 1,100 m of Tortonian, and has not yet been drilled through. The Sarmatian consists of 20 horizons, as in all the fields of the Steinberg fault, which consist of the same groups as those in the correlation profile, although they are separated by thicker clay-marl strata. Dry gas, free from condensable hydrocarbons, is found in the Lower Pannonic and in Sarmatian horizons 1,2,3,5,6,9,10,11,13,18,19, and 20. The gas-containing sands are thin in spots, however, and many vertical displacements up to 50 m in height, affect the distribution of gas. The Tortonian contains 27 correlatable sand strata. Gas has been found in the first, second, fifth, and seventh. Horizons 18 to 27 contain oil, the twenty-fourth contains gas. The density of the petroleum rises from 0.833 in the twenty-seventh to 0.909 in the eighth.

The Goestling, RAG, and Gaiselberg fields are connected to the Steinberg fault by bent structures (Friedl, 1935; Janoschek, 1955). The oil is found primarily in the Sarmatian horizons, although the output from these deposits represents but a small percentage of the total in the Vienna Basin.

In the area west of the Steinberg fault, the Neusiedl-St. Ulrich deposits were discovered between 1941 and 1944. The dominant component is a mountain of Flysch buried in the Helvetian. This underground Flysch massif is 5 km long from east to west, and 1.5 km wide. The Flysch forms an unbroken dome consisting of productive glauconite sands and intercalated clay-schist strata. In an east-west profile one sees the boundaries of the rocks comprising the surface of the Flysch, while on the northern and southern flanks, the dip is steeper than the slope. The 4 productive layers of sandstone total up to 100 m in thickness at the peak, while on the flanks they decline to some 10 m in thickness.

The oil-impregnated glauconite sandstones are poor in carbonates (1 to 5%). Their binder is primarily siliceous. The effective porosity averages 10%. The permeability is about 1 md. These rocks are both oil-impregnated and oil-producing. There are many clefts in the Flysch, and this increases the porosity and permeability of the rock mass as a whole.

The overlying marl contains many productive layers of sand, which are designated, in ascending order, as horizons I,3,2,1, blue and green. However, only the now almost exhausted No 2 stratum (6.5 m productive thickness) and No 1 (3 m productive thickness) are of practical significance. The edge water in the Flysch and the marl layers is stationary, so that the gas is under pressure.

The Maustrenk field lies on the high block west of the Steinberg fault, about 4 km northwest of Zistersdorf. The strata consist of about 250 m of Tortonian and 400 m of Helvetian marl. The Marl foundation contains 3 lenticular productive sand horizons, totaling 12 m in thickness. The marl sand between 750 and 900 m is also productive. Porosity and permeability show marked variations. Output, like that of the Hohenruppersdorf, and the Alt-Lichtenwarth gas field, is not significant.

Of greater importance, on the other hand, was the discovery of the Zwerndorf gas field in the extensive Marchbogen between Zwerndorf and Baumgarten. The stratification consists of about 660 m Pannonic, 320 m Sarmatian, and about 1000 m Tortonian, while the underlying Helvetian has thus far not been drilled. The Tortonian, which is also the stratum containing the gas deposit, consists of 4 lithological units, forming a flattened dome. The top 150 m consist of alternating sand and clay-marl. This upper group of strata is divided from a 400-m thick sand complex below by 300 m of clay-marl. It is this sand that contains the gas deposit, which is bounded underneath by groundwater. The gas-water contact surface is 1,350 m below sea level. The bottom 150 m consist of basic conglomerate, corresponding to the Aderklaa conglomerate. The gas-bearing stratum is a marly sand of 21% effective porosity and permeability of about 100 md. About a billion Nm^3 of gas was lost due to a gas eruption on 15 March 1952. The latter was not brought under control until 24 February 1954. The gas is 97% methane and contains 5 g/Nm^3 heavy gasoline.

Prospecting of the Kagran field is not yet finished. The Rabensburg deposit, too, is still being prospected. Significant amounts of light petroleum have been found in the twenty-fourth Tortonian.

Distribution of the Producing Horizons and the Problem of the Petroleum Parent Rock in the Vienna Basin

Examination of the sketch map (Figure 1) shows that the long-known oil fields are related to the Steinberg fault, and have developed along with the formation of the latter. The oilfields are partly in the sunken portion and partly on the high block. The small occurrences at Rabensburg and Obely lie in a fault system branching to the northeast, which continues the high throw of the Steinberg fault, so that its northern continuation is of less significance. Matzen and Aderklaa, it is true, lie in the southerly continuation of the Steinberg fault line, but are actually of different origin. The Matzen deposit is related to an anticline structure laid down in the Tortonian. The roughly semi-domelike arching of Aderklaa is most probably of more recent origin, and lies west of the Bockfliess-Aderklaa Fault, on the Aderklaa upthrust block. Its origin may possibly be related to that of the fault. The Zwerndorf, Malacky, and Enzersdorf gas fields lie on a line parallel to the Steinberg fault, about 20 km farther to the east. This distribution would seem to be related to the underlying strata. The oil fields lie over the Flysch (Aderklaa is in the border zone over a limestone Alpine base). One may expect to find limestone Alpine or central Alpine rocks below the gas deposits.

It would therefore seem that the parent rock should be sought in the Flysch. But, as Friedl has convincingly demonstrated (1935) that the Flysch oil had immigrated from the Neocene, this is no longer an open question.

The clear lack of petroleum deposits in the southern and in parts of the eastern Vienna Basin would seem to be related to the lithological development of the Lower Tortonian and the Helvetian. As we know from prospect wells, the Lower Tortonian in the southern portion of the Vienna Basin is primarily of coarse clastic composition, while the Helvetian is lacking or appears in freshwater faces. We must therefore assume that the bitumens needed for natural gas formation, but not those required for petroleum formation, were present. Also in need of clarification is the occurrence of a light paraffin-base oil in Aderklaa, and a naphthene-base oil at approximately the same depths in nearby Matzen. In the west these deposits are intersected by the Bockfliess fault system. The intermediate steps or depressed blocks adjacent to the west also contain oil, even if but to a very limited degree. Thus, the Aderklaa depressed block yields, at 2,400 m, a paraffin-base oil with a density of 0.822. This oil is thus heavier than that found at 1,700 m in the Aderklaa structure.

The Bockfliess intermediate step produces a paraffin-base oil of 0.827 density at the 1,440 to 1,456-m level. At the same depth, and only a few hundred meters to the east, the Matzen structure yields a crude oil of 0.905 density. In our opinion, this is to be explained by regarding the light oil as being of recent origin. As the Bockfliess fault system apparently dates from late in the Middle Pannonic, the migration of the oil and formation of the deposit could only have occurred later than this. Effective sealing by a uniform clay-marl complex may also have been of significance.

The higher density of the oil in the Aderklaa depressed block, relative to that of the main structure, is explained by the retention of the heavier components during migration. It is therefore not surprising that similar relationships are found in the Neusiedl-St. Ulrich field, and we must assume the Flysch oil to have been formed by migration from the Neocene. The fact is that the density of the crude declines from the Flysch at 0.892 to 0.860, through that of marl stratum No 2 (0.875 to 0.880) to 0.860 in marl stratum No 1. This increase in density with increasing depth, which we explain by an adsorption effect during migration through fissures, stands in contrast to the decline in density with increasing depth observed in the Matzen, Muehlberg and Goesting fields. For Matzen and Muehlberg it may be taken as probable that the deposits had been formed in the Tortonian, so that the migration occurred as the strata settled.

Muthenthaller and Edelmann, in an unpublished report, have dealt with the problem of clarifying the structure of the crude. The most significant result of their work is illustrated in Figure 4. It will be noted that the ratio of naphthene to aromatics in the crudes of the Vienna Basin is independent of the paraffin hydrocarbon content and the depth from which the oil is recovered. The Aderklaa crude, however, is remarkable for its particularly low content of aromatics.

The same figure depicts the chemism of the water in the deposits. Its concentration is below that of sea water. High carbonate content is characteristic for the Tortonian water of Muehlberg, the water of the sixteenth Tortonian, and the Helvetian of Matzen, while the Helvetian reveals the highest Ca and Mg levels.

Similar high Ca and Mg content, with low carbonates are found in the Flysch and marl of Neusiedl. The water of the Aderklaa deposits is closest to being a pure NaCl solution. The high content of organic acid salts, first reported by Passler, in an unpublished report, is astonishing. Although the relationship between the nature of the crude, the type of water in the deposit, and rock chemism has not yet become clear, it may already be stated that the high carbonate content in the sixteenth Tortonian and in the Matzen Helvetian cannot be ascribed to surface influences.

The question as to whether the paraffin-base oils are primary cannot be answered within the limited area of investigation. For those deposits which show lighter crudes as depth increases (Matzen, Muelberg, Goesting), early formation (Tortonian, Sarmatian) is probable. But at Aderklaa and Neusiedl we must think in terms of a later (Pannonic) migration.

The Vienna Basin reveals no oil-bearing parent rocks with outstanding bitumen content, as Krejci-Graf made clear (1955). We are therefore compelled to regard the gray clay-marl of the Tortonian and the Helvetian as the parent rock. The frequently high pyrite content of the rocks -- this mineral often coats deposits of Foraminifera shells -- indicates deposition under conditions of reduction. With its total of about 90,000,000 t of recoverable petroleum, coming to 8,000 t/km^3, and 30 billion Nm^3 of natural gas (including gas in pockets and releasable from solution), the Vienna Basin may be ranked as a rich petroleum deposit. Figure 5 illustrates the distribution of its reserves among its various fields. Of the gas reserve, one half is at Zwerndorf and the other at Matzen. The reserves of the other fields total only about 5% of the whole.

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FIGURES

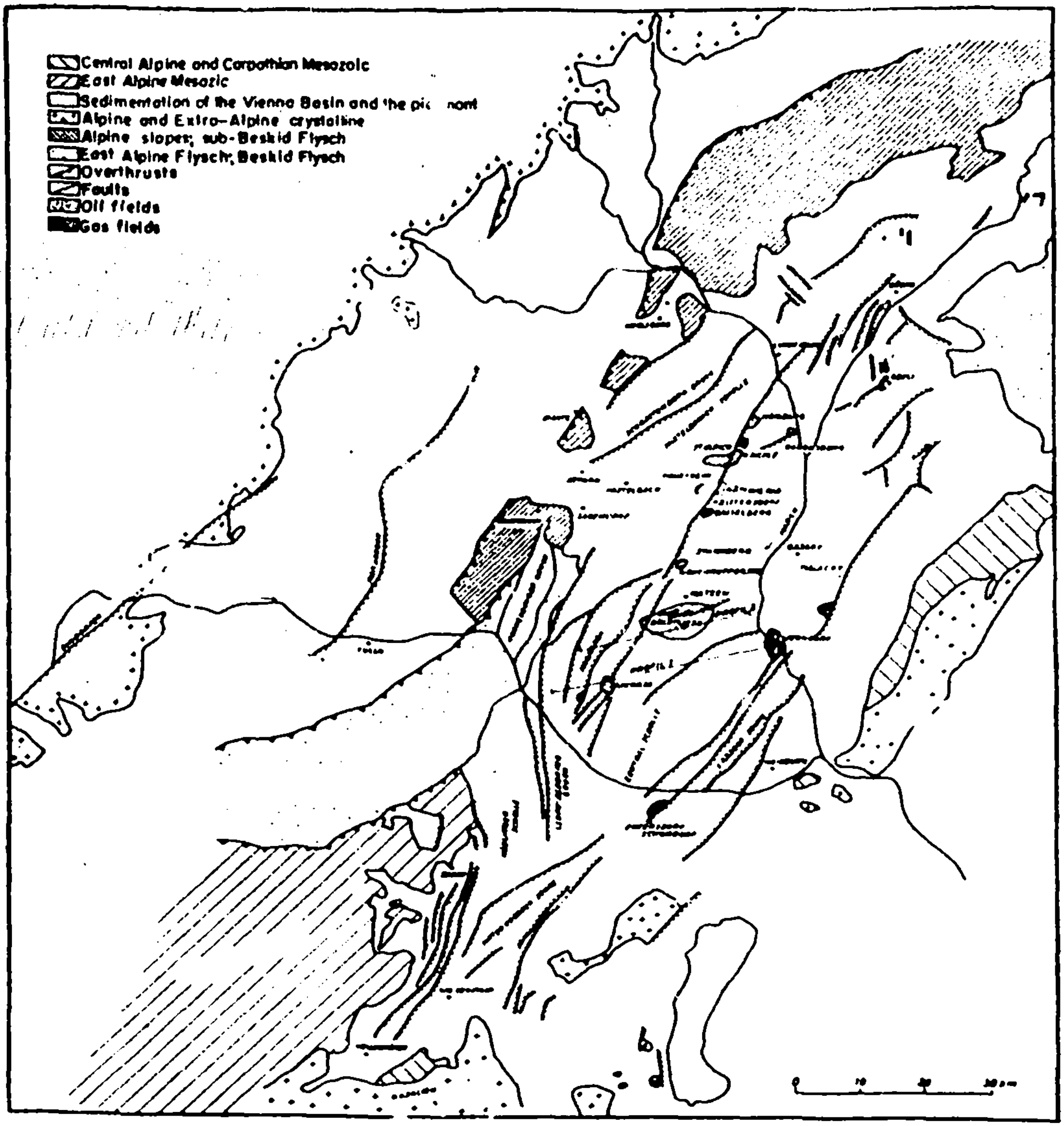

Figure 1. Tectonic sketch of the Vienna Basin. Based on surveys by Brix, Friedl, Grill, Janoschek, Koelbl, and Kuepper; correlated by Wieseneder.

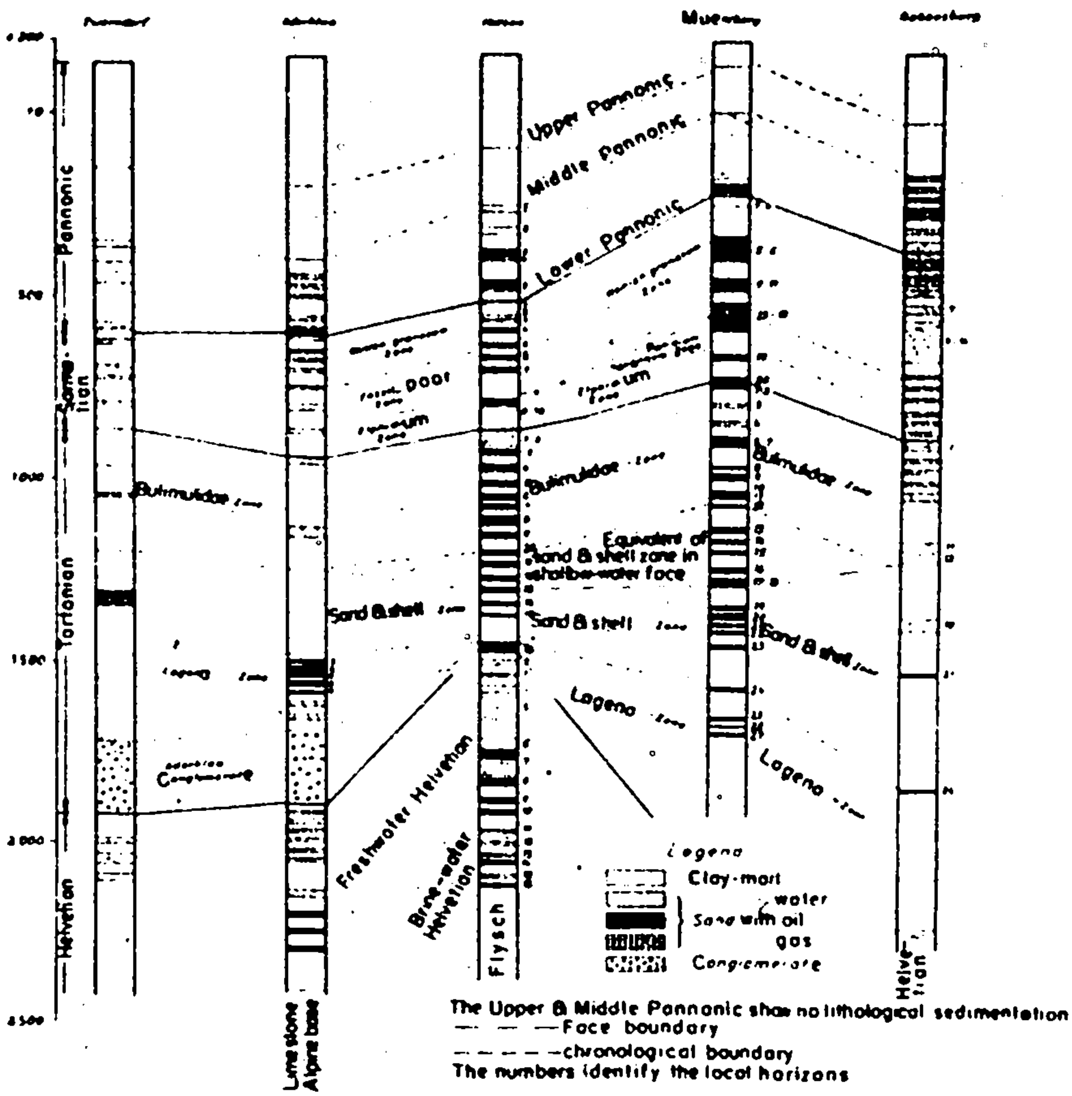

Figure 2. Correlation of the most important geological profiles in the Vienna Basin.

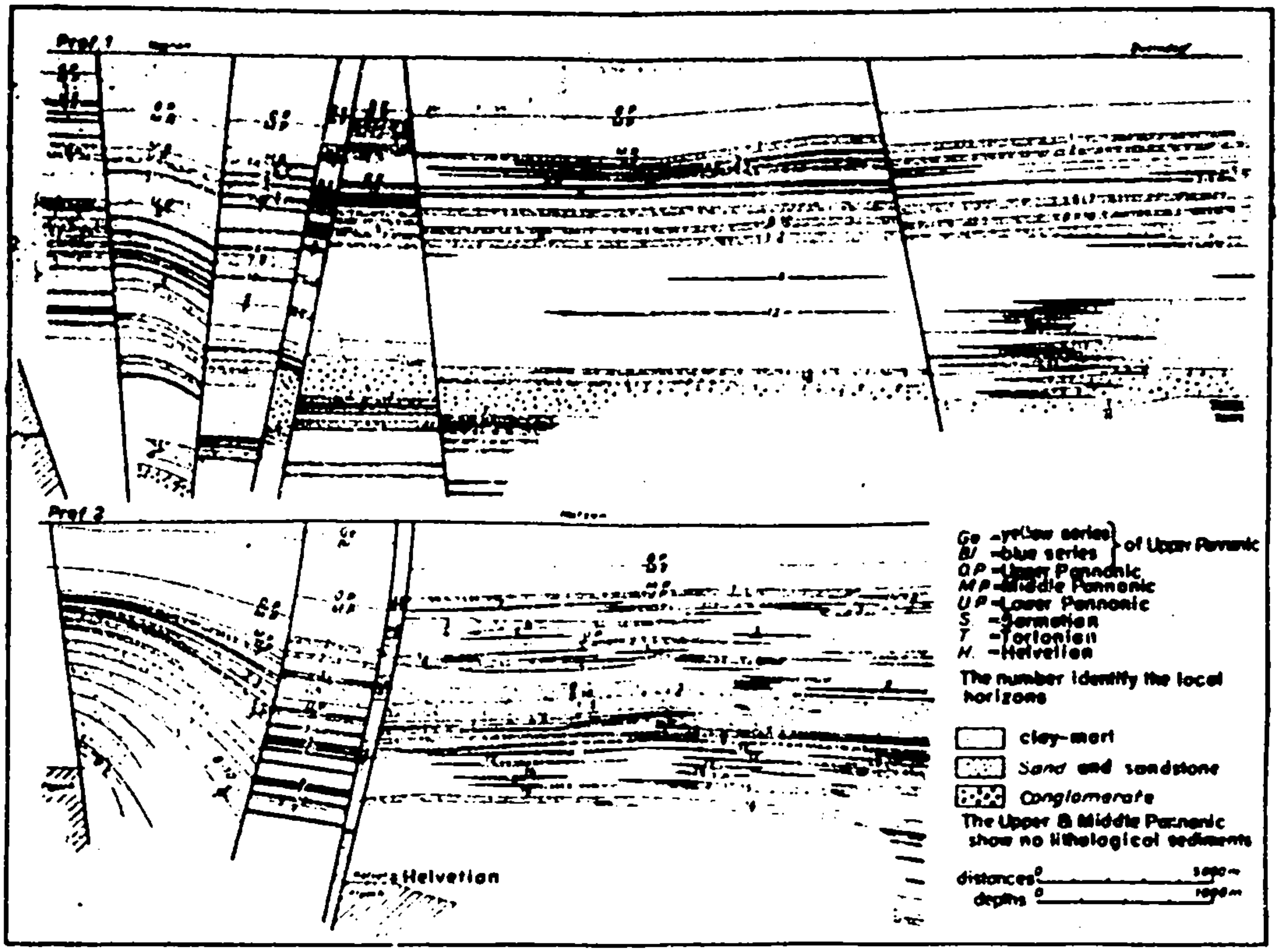

Figure 3. Lithological profile through the Vienna Basin.

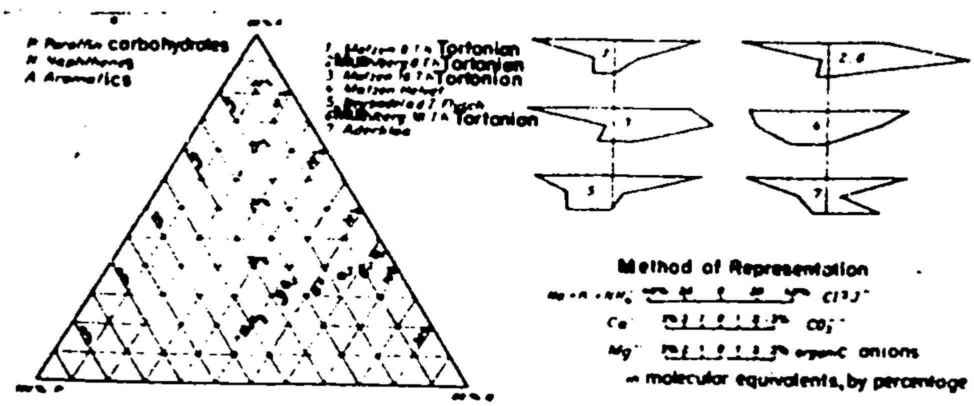

Figure 4. Correlation of crudes and associated waters.

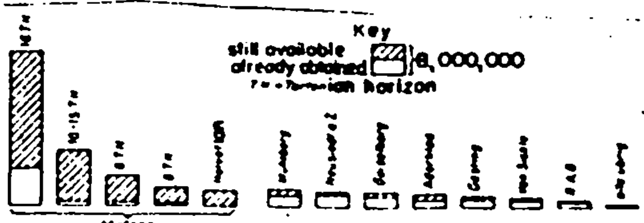

Figure 5. Distribution of estimated oil reserves (January 1956).

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